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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		(11) International Publication Number:
F16D 3/79	A1	WO 92/15798
		(43) International Publication Date: 17 September 1992 (17.09.92)

(21) International Application Number: PCT/GB92/00367

(22) International Filing Date: 2 March 1992 (02.03.92)

(30) Priority data:
9104337.2 1 March 1991 (01.03.91) GB

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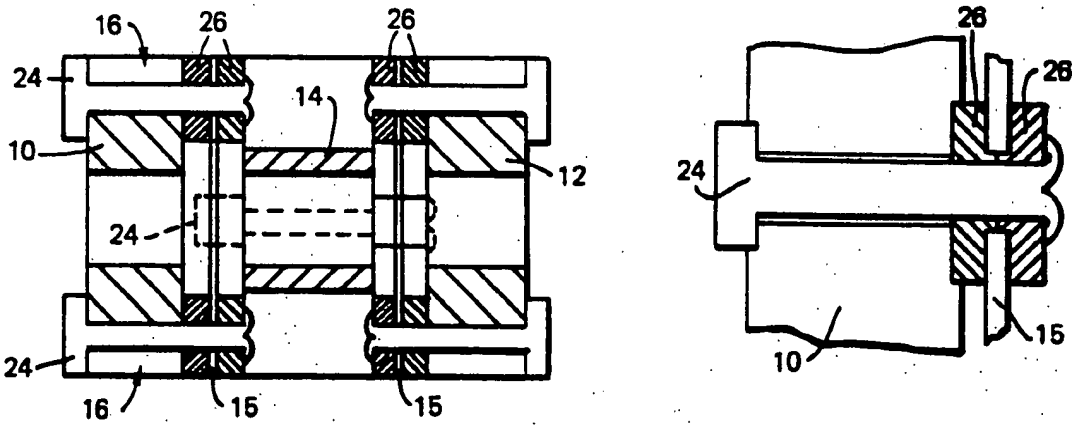
(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB, GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), MC (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.

(54) Title: SHAFT COUPLINGS AND METHODS OF MANUFACTURE THEREOF



(57) Abstract

A flexible coupling for connecting two shafts comprises two hubs (10, 12) with an intermediate member (14) therebetween and two membranes (15), all in axial alignment. Hub (10) is secured to one membrane (15) by fasteners (24) and hub (12) is similarly secured to the other membrane (15). The two membranes are coupled to the intermediate member (14) by further fasteners (24). The fasteners (24) extend through holes in the membranes with clearance. The fasteners (24) are located within peripheral slots (16) in the hubs (10, 12) so that the hubs do not have to be provided with precisely located and dimensioned holes for the fasteners. Upon axial compressive loading, washers (26) flanking the membranes will become embedded in the hubs and may flow to take up the clearance spaces. If steel washers are used, the clearance spaced are instead filled by swelling of the fasteners (24) when the fasteners are staked to retain the compression. The fasteners (24) may be semi-tubular rivets, nuts and bolts, or threaded rivets with nuts.

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SHAFT COUPLINGS AND METHODS OF MANUFACTURE THEREOF

This invention relates generally to shaft couplings and to methods of manufacture thereof, and is more particularly concerned with membrane couplings.

Shaft couplings are used to transmit rotation from one shaft to another with the shafts placed end to end. They can be classified as "solid", when the two shafts are maintained in a fixed relationship, or as flexible, when the construction permits relative displacement of the two shafts during rotation. To a greater or lesser extent this displacement can be longitudinal, torsional, angular, lateral or any combination thereof.

In some circumstances it is a requirement that torsional displacement is eliminated. Such couplings are referred to as torsionally rigid, flexible shaft couplings. One type of torsionally rigid flexible shaft coupling is known as a membrane coupling. The methods of construction, materials and configurations of membrane couplings are diverse. Membrane couplings may have a single plane of engagement between two end connectors, in which case this permits relative angular shaft displacement. For membrane couplings which have two planes of engagement, the coupling will permit relative angular and lateral shaft displacement. All membrane couplings can accommodate longitudinal shaft displacements to a greater or lesser extent.

Typically, the construction of a membrane coupling with a single plane of engagement comprises three coaxial members, i.e. two hubs for connection to the input and output shafts respectively and an intermediate flexible membrane to which the hubs are securely connected by threaded or riveted fasteners

which pass through holes through the hubs, and with spacers that maintain a clearance between the adjacent faces of the three members in order to permit limited flexing of the membrane about its attachment locations. The membrane may be a flexible disk or alternatively can be constructed from a number of partially superimposed links in the manner of a roller chain. In the case of a disk this is usually metallic and can have an aperture concentric with its outline, which may be circular, polygonal or of some other appropriate shape. Whatever the shape, the construction or the material of the membrane, its function is to act as a hinge in two planes while remaining rigid in torsion. It is common for a membrane to be attached and suitably secured to each of the two hubs, with the resulting sub-assemblies being attached and suitably secured to an intermediate member located on the common axis. Such an arrangement, with two planes of engagement, permits relative lateral displacement of the hubs.

In one simple known construction of membrane coupling, having a single plane of engagement, the membrane disk is provided with four equispaced holes on a pitch circle diameter centred on the rotational axis of the coupling. Two diametrically opposed holes are used securely to attach the disk to one hub, and the other two holes are used securely to attach the disk to the second hub. As concentricity of the bores through the first and second hubs is essential for correct operation of the coupling, the complementary attachment holes provided through each hub must lie on a pitch circle diameter which is both concentric to and identical with the pitch circle diameter of the holes provided in the disk. When the bores through the first and second hubs are in concentric relationship, the four pairs of complementary holes provided in the hubs

and disk are intended to align precisely with one another, thus permitting the insertion of close-fitting fasteners to maintain the hubs in a fixed torsional relationship. In practice however, both the diameters and the geometric locations of these holes are subject to manufacturing tolerances, thus forcing one to reduce the nominal shank diameter of the fasteners relative to the nominal diameter of the holes through which they pass. The necessity for this clearance between hole and fastener has the disadvantage that it can permit torsional free play between the first and second hubs, and some alternative means must be provided in order to render the coupling free from torsional free play. This means is provided in known membrane couplings by the fastening itself. In the case of a threaded fastener such as a nut and bolt, the nut is torqued to a value known to be within the elastic limit of the bolt, and the resultant tension maintains the adjacent members in a compressive state which is sufficient to restrain relative movement. In the case of a rivet as the fastener, the type most commonly used is a semi-tubular rivet. In this case the adjacent members, which may include a spacer on each side of the membrane disk, are put into compression while the end of the tubular rivet is turned over.

In all these known constructions of membrane coupling the torsional integrity of the coupling is determined by the frictional restraint generated by the fasteners. This may yield a lower torsional value than the proof stress of the materials used in the construction, and the torsional capacity of the coupling is thereby reduced.

Yet a further disadvantage of the manufacture of membrane couplings in the manner outlined above is the relatively high cost of manufacture, due to the

high level of precision needed in the creation of the holes and the close tolerances which have to be applied.

One object of the present invention is to provide a membrane coupling which has improved torsional integrity which is not reliant solely on frictional restraint.

It is a further object of the present invention to reduce the cost of manufacture of membrane couplings by using parts which can be manufactured at low cost and by avoiding the need for manufacture of the parts to the close tolerances previously required. The concentricity of bores, hubs, membranes and any intermediate members is achieved through means other than by the application of close tolerances to the positions of the holes and to the diameters, such as are normally associated with the manufacture of membrane couplings.

It is a preferred feature of the present invention to provide a membrane coupling which utilises an improved fastening between the membrane or membranes on the one hand and the hubs and any intermediate member or members on the other hand. This feature is based upon an acceptance of the fact that if one has a fastener extending through a hole then there must be some clearance, no matter how precise the manufacture and no matter how close the tolerances to which one is working. Therefore, according to this preferred feature of the present invention one goes away from the concept of attempting to work with improved precision and instead to increase the clearances, instead of reducing them, and to use an alternative means for achieving the required torsional integrity of the coupling.

In accordance with the present invention

there is provided a flexible coupling for connecting two shafts, comprising first and second members and a membrane therebetween, the members being in axial alignment and the members and the membrane being coupled together under compression by fasteners extending through holes in the membrane, and washer means at least between the membrane and each said member, wherein the fasteners extend through the first and second members with substantial freedom for movement relative to the said members prior to compression of the coupling.

Preferably, the fasteners are located within peripheral slots in said first and second members. This means that the members do not have to be provided with precisely located and dimensioned holes for the fasteners. By virtue of this, the members and any intermediate member can be extrusions, thus substantially reducing manufacturing costs.

The said members may be two hubs, each for connection to a shaft. Alternatively, the said members may be one hub and an intermediate member, with a second membrane and additional hub fastened in serial aligned axial relationship, in order to provide two planes of engagement.

In accordance with a preferred feature of the invention the material of the washer means is such that upon compression of the coupling it flows into the clearances between the fasteners and the holes in the membrane.

The holes in the membrane between the hubs or between the hubs and any intermediate member can be of any desired shape. One is not restricted to accurately circular holes because the washer material will flow to take up whatever clearance space is available. The cold flow of washer material in the assembly operation

eliminates all possibility of play anywhere in the coupling.

Also in accordance with the invention there is provided a method of manufacture of a flexible coupling which comprises positioning first and second members with a membrane therebetween in axial alignment with fasteners extending through holes in the membrane and extending through said first and second members with substantial freedom for movement relative to the said members, and exerting an axial compressive loading on the assembly including securing of the fasteners, thereby to fill the clearance spaces between the fasteners and the holes in the membrane.

In order that the invention may be fully understood, presently preferred embodiments of membrane coupling in accordance with the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 is an end view of a first embodiment of membrane coupling;

Fig. 2 is a cross-sectional view through the membrane coupling of Fig.1, taken along the line II-II of Fig. 1;

Fig. 3 is a cross-sectional view through the membrane coupling of Fig. 1, taken along the line III-III of Fig. 1;

Fig. 4 is an end view of one of the hubs of the membrane coupling;

Fig. 5 is a detail view on an enlarged scale to show the flow of material;

Fig. 6 is an end view of one of the flexible disks of the membrane coupling;

Fig. 7 is a partial, schematic illustration of the pressing operation utilised in the assembly of the membrane coupling;

Fig. 8 is the view in the direction of the arrow A in Fig. 7;

Fig. 9 shows an alternative, bolted construction of membrane coupling; and,

Fig. 10 shows a further alternative fastening for a membrane coupling of the present invention.

Referring to the drawings, there is shown a membrane coupling which comprises two hubs 10 and 12 adapted for connection to respective rotatable shafts (not shown) which are in general axial alignment. Between the hubs 10 and 12 is positioned an intermediate member 14. Between each hub 10, 12 and the intermediate member 14 are respective membranes 15. The hubs 10 and 12 are preferably extruded and have a shape, in end view, as shown most clearly in Fig.4. The hubs 10, 12 are preferably made from aluminium or an aluminium alloy, although other materials can alternatively be used. Each hub 10, 12 has two identical, diametrically opposed narrow slots 16 and two identical, diametrically opposed wider slots 18 offset at 90° to the narrower slots 16. Each hub 10, 12 has a central hole 20 therethrough.

The membranes 15 are preferably thin metallic membranes, made for example from stainless steel or beryllium copper. One example of a membrane in the form of a flexible disk is shown in Fig. 6. Here the disk is annular and is provided with four equispaced holes 22 therethrough. In the embodiment illustrated in Fig. 6 the holes 22 are circular, although within the scope of the present invention these holes could be oval, square or of any other shape.

The securement of the hubs 10 and 12 to the membranes 15 and the securement of the intermediate member 14 to the membranes 15 is effected by fasteners which are here shown in the form of semi-tubular rivets

24. In the case of the hubs 10 and 12, two rivets 24 connect each hub to the associated membrane 15, these two rivets being located in the diametrically opposed narrower slots 16 in the hubs, with the heads of the rivets in contact with the outer end faces of the hubs. The shanks of the rivets 24 are a loose fit within the slots 16. A pair of washers 26 are provided on the shank of each rivet on each side of the associated membrane 15, as shown most clearly in Fig. 5. The washers 26 are of a softer material than the membranes 15. The hubs 10, 12 and the washers 26 are of unequal hardness so that under compression the parts will become embedded and thus prevent the subsequent occurrence of relative radial and rotational movement. A non-ferrous material such as brass has been found to be particularly advantageous for the washers 26. As shown in Fig. 3, equivalent rivets 24 and washers 26 are provided for the securement of the intermediate member 14 with the flexible membranes 15 on each side thereof. Here, the rivet head abuts one face of one membrane 15, with a first washer on the opposite side of that membrane in abutment with the intermediate member 14 and two washers 26 are provided on the shank of the rivet on each side of the other membrane 15.

The membrane coupling is made by a two-stage setting and securing assembly operation. Each hub 10, 12 is first assembled with the associated membrane 15, by using a locating device and locating pins to align the parts. The parts are first set, i.e. placed under compression, and then secured by turning over the rivets. The two sub-assemblies are then attached to the central intermediate member 14 as a separate setting and securing operation. It will be appreciated that the wider slots 18 in the hubs 10 and 12 permit access to be gained for the tooling to insert and set the

rivets 24 which secure the membranes to the intermediate member 14. These wider slots 18 also give clearance for the rivet heads during operation of the membrane coupling.

If two materials of different hardness are compressed together, the softer material will cold flow along the path of least resistance. Thus, when the two hub sub-assemblies are put into compression, and again when the sub-assemblies are to be joined to the intermediate member, again under compression, the relatively soft material of the washers 26 will flow into any available clearance space, notably to fill the holes 22 in the membranes 15. The cold flow of material into the clearances in this manner not only gives enhanced frictional grip but also gives a substantial mechanical constraint, which again is advantageous. As can be seen most clearly from Fig. 5, in the setting operation, the heads of the rivets 24 will become embedded within the material of the hubs 10 and 12 and the washers 26, as well as flowing into the clearances, will also become embedded to a greater or lesser extent in the material of the hubs 10 and 12.

Figs. 7 and 8 illustrate how the pressing operation may be carried out in the assembly of the membrane coupling. Figs. 7 and 8 show the securement of one of the hubs 10 to a membrane 15 by the use of two rivets 24. The tooling for the pressing operation is indicated generally at 34. A first press tool 36 which has two annular bushes 38 has respective punches 40 projecting proud of the bushes so that the punches can first be located in the rivets as the press tool is lowered. Then, the bushes make contact with the facing washers 26 and put the components of the sub-assembly under compression, causing the cold flow process to take place. When the parts have been compressed to a

predetermined pressure, the punches 40 are caused to press the rivets 24 to roll these over and stake the rivets in place, retaining the compression. The two completed sub-assemblies are then secured to the intermediate member 14 in similar manner.

It should be appreciated that although in this preferred embodiment there is shown a membrane coupling comprising two hubs, an intermediate member and two membranes, one could alternatively have just two hubs with a single membrane therebetween, or alternatively a greater number of axially arranged hubs and membranes, as circumstances require.

Also, although in the preferred embodiment the hubs 10 and 12 are shown as having peripheral slots 16 and 18, these slots could be replaced by holes through the thickness of the hubs, of sufficient diameter loosely to accommodate the shanks of the fasteners. However, as mentioned above, slots are preferred because of the low cost of manufacture and the greater access for ease of assembly.

Although in the embodiment described above washers of relatively soft material are used to flow into the holes in the membranes, it has been found that one can alternatively use steel washers which do not cold flow. With such washers, upon putting the assembly or sub-assemblies under compression, the washers will become embedded in the adjacent material. When the rivets are then staked the rivets will swell across their diameters. This is most pronounced at the impacted end in the proximity of the tubular portion of the rivet. The swelling takes up any clearance between the shank of the rivet and the hole in the membrane, and thus reduces any clearance to zero.

A bolt suitably tensioned with a nut can be used as an alternative to a tubular rivet. Fig. 9

shows one such bolted assembly utilisable in a coupling according to the invention. The bolt 44, as with the rivets, has its shank located within a slot in the hub 10. The shank of the bolt passes through the membrane 15. The membrane 15 is flanked by steel washers 26 with copper washers 46 between the steel washers and the membrane. A nut 48 is fitted to the bolt. Because of the slotted nature of the hubs one can readily gain access to the bolt to tighten it to the desired torque.

While the rivetted construction functions well, it does not permit replacement of the membranes, should these fail in service. This may be a disadvantage with large size couplings. For such couplings the bolted construction may be considered preferable. A preferred solution is to combine the two structures, using a semi-tubular rivet machined from hexagon, or flatted, stock and threaded at its end so that it can be tensioned with a nut. The purpose of the hexagon stock is to provide purchase for a spanner against which to torque down the nut. This is shown in Fig. 10. The rivet is shown generally at 50, the hexagonal portion at 52 and the nut at 54. Fig. 10 shows both the bolt/rivet in its pretensioned state and also the finished assembly. As before, the assembly is put under compression, after alignment of the parts, by tightening of the nut 54. When the tubular end of the bolt/rivet is then staked this portion of the bolt/rivet swells to fill the hole in the membrane where the compressive force has caused swelling of the rivet in the hole in the membrane 15.

CLAIMS:

1. A flexible coupling for connecting two shafts, comprising first and second members and a membrane therebetween, the members being in axial alignment and the members and the membrane being coupled together under compression by fasteners extending through holes in the membrane, and washer means at least between the membrane and each said member, wherein the fasteners extend through the first and second members with substantial freedom for movement relative to the said members prior to compression of the coupling.

2. A flexible coupling as claimed in claim 1, in which the fasteners are located within peripheral slots in said first and second members.

3. A flexible coupling as claimed in claim 2, in which at least one of said members is a substantially cylindrical member with two pairs of diametrically opposed peripheral slots, the slots being set 90° apart.

4. A flexible coupling as claimed in claim 3, in which the slots of one pair are larger than the slots of the other pair.

5. A flexible coupling as claimed in any preceding claim, in which the first and second members are made from extruded material.

6. A flexible coupling as claimed in any preceding claim, in which the material of the washer means is such that upon compression of the coupling it flows into the clearances between the fasteners and the holes in the membrane.

7. A flexible coupling as claimed in claim 6, in which the washer means are of copper or brass.

8. A flexible coupling as claimed in any

preceding claim, in which the fasteners comprise semi-tubular rivets.

9. A flexible coupling as claimed in any of claims 1 to 7, in which the fasteners comprise bolts and nuts.

10. A flexible coupling as claimed in any of claims 1 to 7, in which the fasteners each comprise a semi-tubular rivet having a threaded portion at the end remote from the tubular portion to receive a nut.

11. A flexible coupling as claimed in any preceding claim, in which the first and second members are two hubs, each for connection to respective shafts to be coupled together.

12. A flexible coupling as claimed in any of claims 1 to 10, in which the first member is a hub for connection to a shaft, and the second member is an intermediate member, with a second membrane and an additional hub fastened in serial aligned axial relationship, thereby to provide two planes of engagement.

13. A method of manufacture of a flexible coupling which comprises positioning first and second members with a membrane therebetween in axial alignment with fasteners extending through holes in the membrane and extending through said first and second members with substantial freedom for movement relative to the said members, exerting an axial compressive loading on the assembly, and securing the fasteners in place to retain the compression, the compression and/or securing steps causing filling of the clearance spaces between the fasteners and the holes in the membrane.

14. A method as claimed in claim 13, in which the fasteners are located within peripheral slots in said first and second members.

15. A method as claimed in claim 13 or 14, in

which the fasteners comprise semi-tubular rivets.

16. A method as claimed in claim 13 or 14, in which the fasteners comprise bolts and nuts.

17. A method as claimed in any of claims 13 to 16, in which the material of washers flanking the membrane is caused to flow into the clearance spaces when the axial compressive loading is exerted.

18. A method as claimed in any of claims 13 to 16, in which the clearance spaces are filled by swelling of the fasteners in the securing step.

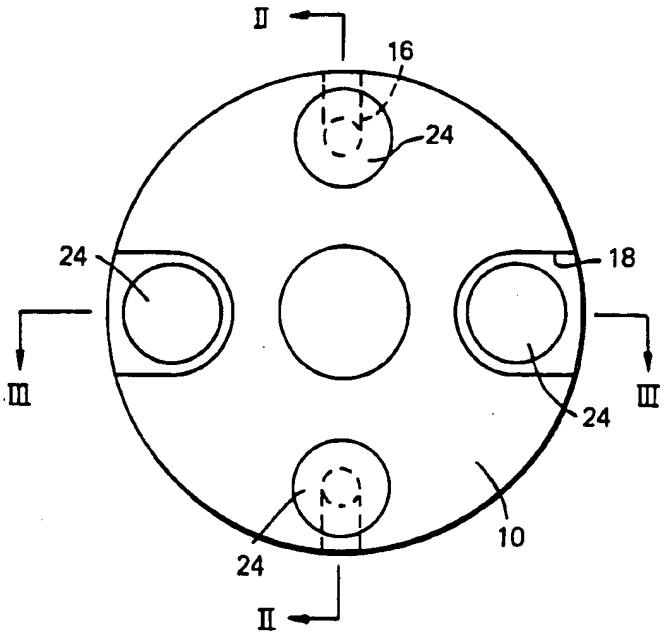

FIG. 1

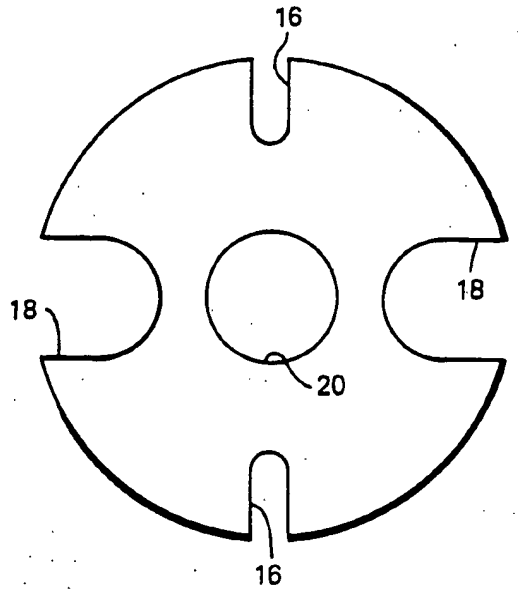

FIG. 4

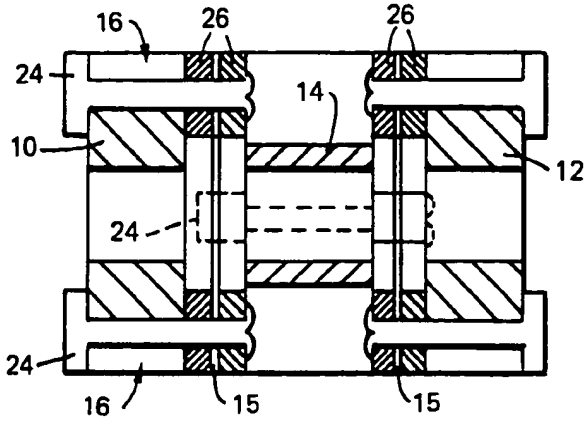

FIG. 2

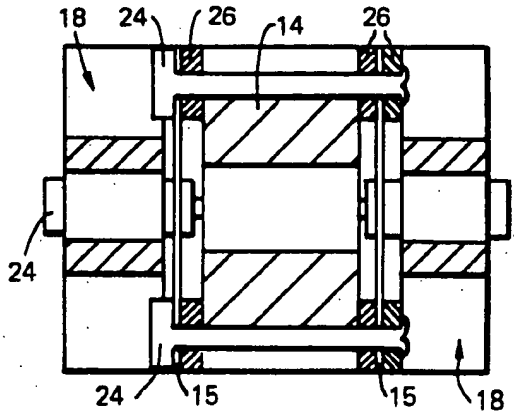

FIG. 3

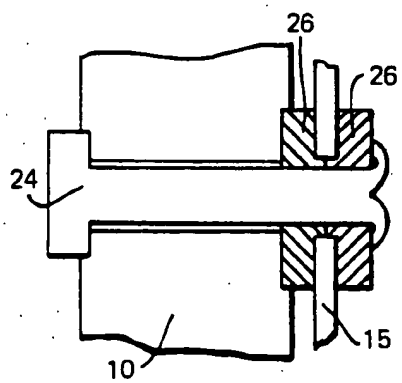

FIG. 5

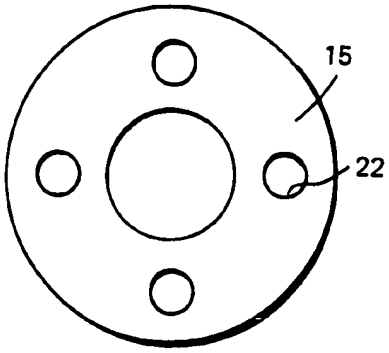

FIG. 6

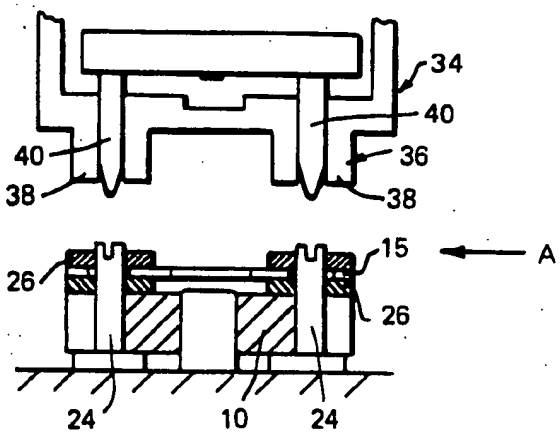

FIG. 7

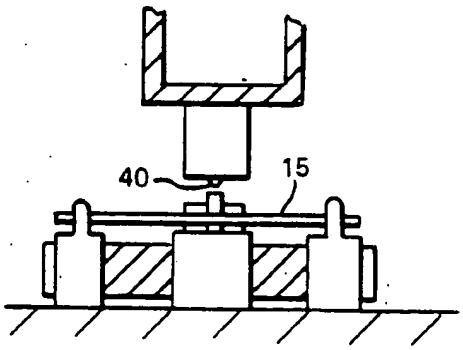

FIG. 8

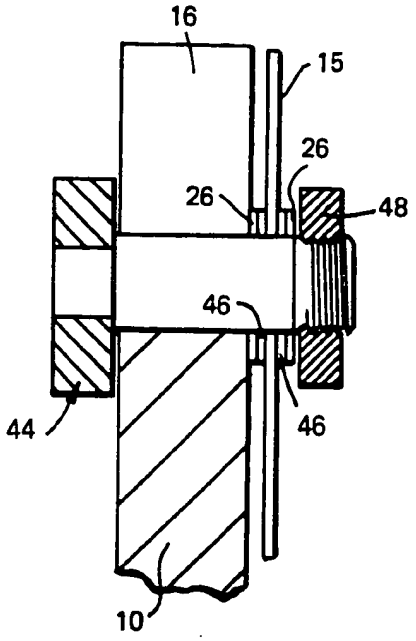

FIG. 9

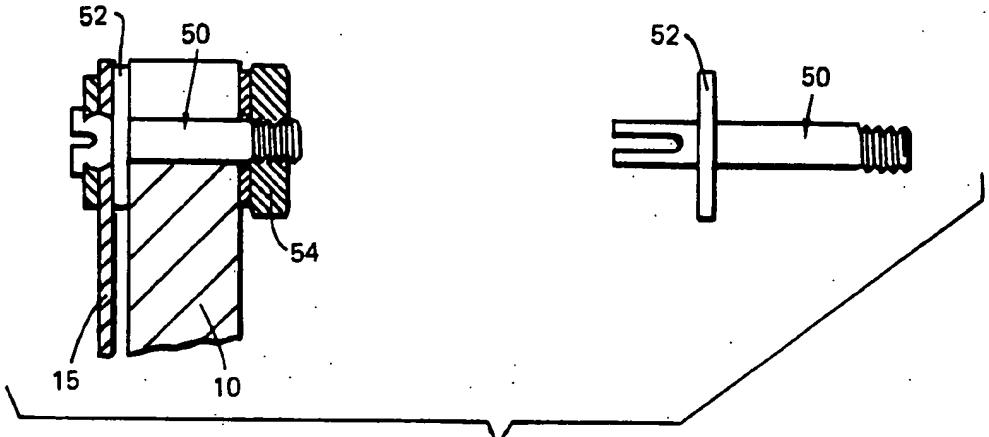

FIG. 10

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 92/00367

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.5 F 16 D 3/79

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl.5	F 16 D

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	US,A,2430449 (A. BROWN) 11 November 1947, see the whole document	1
A	---	2,3
A	DE,C,3822207 (REXNORD) 26 October 1989	

° Special categories of cited documents :[10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
25-05-1992	22. 06. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	Maria Peis

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9200367 SA 57171

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 18/06/92 The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 2430449		None	
DE-C- 3822207	26-10-89	DE-A- 3869406	23-04-92
		DE-U- 8816531	12-10-89
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		US-A- 5019015	28-05-91